
A P P E N D I X C

Accessibility

This appendix presents recommendations for computer and component design related to lowering access barriers to computer use for persons with special physical needs.

These guidelines were developed in consultation with the Trace Research and Development Center at the University of Wisconsin-Madison and were based on research funded by the National Institute for Disability and Rehabilitation Research (NIDRR). For more information, see the references at the end of this appendix.

For information about software accessibility guidelines, see the web site at <http://www.microsoft.com/enable/>.

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Introduction

Personal computers are powerful tools that enable people to work, create, and communicate in ways that might otherwise be difficult or impossible. The vision of making computers easier for everyone to use, however, can be realized only when people with disabilities have equal access.

Computer accessibility has become an increasingly important issue in the home and workplace. An estimated eight out of ten major corporations employ people with disabilities who might need to use computers as part of their jobs. In the United States alone, more than 30 million people have disabilities that affect PC accessibility. In addition, as the post-war generation ages and more people experience functional limitations, computer accessibility will become a more important issue. Addressing disabilities in design will benefit all users by creating an interface that is easier to use and better able to adapt to the differing usage and environments faced by users.

In the United States, legislation such as the Americans with Disabilities Act and Section 508 of the Rehabilitation Act has brought accessibility to national attention in both the public and private sectors. The Telecommunications Act also mandates accessibility wherever it is readily achievable for products that are used for telecommunications. Accessibility is also being incorporated into official and international standards for usability, such as ANSI 200. Such recommendations affect the following:

- Visual displays and indicators
- Sound
- Manipulation and physical design
- Input devices and software controls
- Labeling
- Documentation

What Are Disabilities?

Individuals are not disabled; rather, some people have difficulties performing certain tasks, such as using a mouse or reading small print. When these limitations are serious enough to impact the person's performance, they are referred to as "disabilities." Anyone can experience the same difficulties because of illness, accident, environment (such as loud background noise), or hardware error (such as a missing mouse).

Disabilities can be classified into the following general categories:

- **Visual impairment.** This ranges from slightly reduced visual acuity to total blindness. Those with reduced visual acuity might only need images to be reasonably sized or specially enlarged, or they might need high contrast between foreground and background. Users with more severe impairments might require that output be translated into audible cues, spoken text, or Braille.
- **Hearing impairment.** Some individuals do not hear beeps, distinguish different sounds, or recognize spoken words. These users might need the computer to prompt them in a different manner, such as a screen flash, an indicator lamp, or an on-screen message.
- **Movement impairment.** Some users are unable to perform certain manual tasks, such as using a mouse or typing two keys at the same time. Others might have a tendency to hit multiple keys, might "bounce" fingers off keys, or might be unable to hold a printed book. Many users need keyboards and mouse functions adapted to their requirements, or they may rely exclusively on a single input device.
- **Cognitive impairment.** Cognitive impairments take many forms, including memory loss, perceptual differences, and conditions such as Downs syndrome. Language impairments such as dyslexia or illiteracy are also very common. Those who speak English as a second language can be considered to have a form of language impairment. Proper design can increase accessibility for these computer users.
- **Seizure disorders.** People with some forms of epilepsy might experience minor or severe seizures when a monitor flashes at certain rates or they hear certain types of random or repetitive sounds.
- **Speech impairments.** Although speech difficulties do not normally affect a person's ability to use a computer, it can be a problem in using telecommunications and voice menus. And in the future, speech difficulties might affect normal computer usage if voice recognition becomes a common form of input.

What Is Accessibility?

Accessibility means making computers accessible to a wider range of users than would otherwise be the case. Special needs can be addressed in several ways:

- New features built into hardware and operating systems help make computers accessible to users with and without specialized needs. These solutions, often referred to as “electronic curb cuts,” are preferred because the features are available on all workstations and can be used with all applications.
- Usability features can be built into mainstream products, making them easier to use for people with disabilities. Examples include customizable colors and keyboard accelerators. In many cases, these features also benefit people without disabilities.
- Utilities that upgrade a system make the PC more usable by people with disabilities. Examples of utilities include Braille-output systems for people who are blind or software that modifies the behavior of the keyboard and mouse.
- Specialized applications, such as a word processor designed to integrate voice and text, help individuals with limited reading and writing skills.

A variety of hardware and software products have been designed to help people with disabilities make use of PCs. Following are some of the different products available for upgrading the accessibility of the Microsoft Windows operating system:

- Programs that enlarge or alter the color of information on the screen
- Programs that describe on-screen information in Braille or synthesized speech
- Hardware and software utilities that modify the behavior of the mouse and the keyboard
- Programs that enable users to “type” using a mouse or their voice
- Word or phrase prediction software that allows quicker typing with fewer keystrokes
- Alternative input devices, such as single-switch or puff-and-sip devices

Visual Displays and Indicators

Visual display is the predominant form of display on today's computers. This includes the standard display screen, light-emitting diode (LED) or liquid crystal display (LCD) icon displays on or near the keyboard, and special visual indicators on peripheral devices.

For people with low vision or blindness, these displays are a barrier to computer use. Special screen-magnification software can increase the image size for people with low vision. Similarly, software "screen readers" can access information and read it aloud to users who are blind. Information provided by indicator lights or LCD mini-displays, however, must also be made available and readable.

Hardware design strategies for providing greater access to visual information include the following:

1. Minimize glare.

Glare caused by reflections or mismatched color combinations, overly bright indicators, and so on might present problems for users with low vision. Minimizing glare allows these users greater access to displays.

2. Avoid 5-Hz to 50-Hz refresh rate or flicker rate.

This allows users with photosensitive epilepsy, who might have a seizure if exposed to strong stimuli in the 5-Hz to 50-Hz range, to more safely use the system.

3. Make LCD and LED indicators, warning lights, and alert lights software-readable.

This allows users who are blind to use their screen-reading software to access important indicators, warnings, and notices.

The following standard design practices also facilitate accessibility:

4. Provide contrast and brightness controls.

This is important for users with low vision and color blindness, making it possible for them to adjust the display to accommodate their needs and preferences.

5. Provide a display connector for an external or additional monitor.

Users with low vision often need to augment the system with a larger monitor to take full advantage of screen-magnification software. This is especially true for mobile PC users.

6. Provide adjustable monitors.

Users with physical disabilities adjust the angle and position of the monitor to suit their seating position and approach to the system. Other users with low vision often adjust the monitor to reduce glare.

7. Provide audio cue for hardware-generated visual cues.

Any hardware-generated visual cues or warnings should be accompanied by a sound cue. Software-generated alerts can be handled by the software.

Sound

Sound is increasingly being used to convey information important to the computer operator. This includes alerts in addition to speech and other complex audio feedback. This can pose problems for any user on an airplane or in other noisy environments, and it especially can cause problems for those who are deaf or hard of hearing.

Hardware design strategies for providing greater access to aural information include the following:

1. Provide a headphone jack.

Headphone jacks allow users with reduced hearing to block out background noise and make the output louder (by using headphones or by connecting directly to their hearing aids).

2. Maximize the range of volume adjustment.

Volume controls allow users with reduced hearing to adjust the volume level to suit their needs.

3. Direct speakers toward the user or allow user to adjust the speakers.

This maximizes the signal-to-noise ratio (SNR) for all users. This is especially important for users with hearing loss.

4. Provide a visually distinct indicator for all alerts or warning sounds created by hardware.

Visual indicators make recognizing alerts easier for users working in loud environments or for users with deafness or reduced hearing. (Software-generated alerts should be handled by software.)

5. Provide a visual indication of important sounds generated in normal computer operation.

Some natural sounds, such as those generated by a disk drive or printer, can be important to system operation. Where this is true, some visual indication of the sound should be provided so users in loud environments or those with reduced hearing or deafness can effectively use the systems.

6. Send hardware-generated beeps to the operating system.

This allows visual display of beeps for users in loud environments, users located in another room, or users with reduced hearing or deafness. Examples include beeps related to the keyboard and printer.

7. Place the microphone in the orientation recommended by the microphone manufacturer.

Along with speech-recognition software, properly locating the microphone makes the computer more accessible to users who are blind, have low vision, are physically disabled (including those with repetitive strain injury [RSI] and carpal tunnel syndrome), or have difficulty writing.

8. Include a speech-capable sound system.

Such a sound system provides speech capabilities for nonspeaking persons. It also provides the necessary hardware support for a speech-based access system used by people with low vision, blindness, or reading difficulties.

9. Reduce noise level of operating internal components.

This increases the ability of users with neural hearing loss or hearing aids to converse or use computer sound-based features.

Manipulation and Physical Design

Accessibility efforts often focus on the input or display components of a computer. However, many of the physical design characteristics of the computer are equally important. For example, if the person is unable to operate the latches to open a portable computer, other aspects of the computer's design are of little importance.

Some users have conditions that result in weakness or poor motor control. Some have use of just one hand or reduced range of motion or reach. Hardware design strategies for providing greater access include the following:

1. Eject media a sufficient distance for grasping.

Ejecting 0.75 inch or more is helpful for those with reduced hand functions.

2. Sculpt or bevel device or plug entry slots.

This assists in guiding plugs, disks, and other media into connectors or slots for those with reduced motor control. This also gives a tactile indicator, which helps those with low vision locate the plug or slot. CDs should seat themselves properly when dropped into trays (that is, no fine positioning is required from the user). The CD should also be easy to remove from the tray (that is, slots at the sides of the tray allow for placing a finger under the disc to lift it out).

3. Provide self-orienting or clearly tactually marked plugs.

Plugs should be self-orienting or have clear tactile indicators as to the proper orientation for insertion.

4. Make latches operable with one hand.

This allows those who do not have use of limbs or who use assistive pointing devices to operate latches.

5. Minimize the force required for inserting and retrieving media.

This assists those with reduced strength and grasp capabilities. A maximum force of 2 Newtons is advised, but it is preferable for the mechanism to “suck” the disk in for insertion and to not require a force of more than 2 Newtons for pulling it out of the slot.

6. Ensure that media stands up to rough handling; use caddies for media that do not.

This allows individuals with poor motor control to safely handle all media without inflicting irreversible damage.

7. Provide error flags for misinserted media, especially CDs.

When it is not possible to block misinserted media (see item 8 below), the hardware could contain a disk-present detector to warn the user that a disk has been inserted but is unreadable because it is upside-down (and not just in an unreadable format). This would be an asset for users with visual impairments as well as novice users.

8. Ensure that devices do not generate electromagnetic or radio frequency (RF) fields that would affect users with hearing aids.

Electromagnetic fields can couple with induction pick-ups in hearing aids, causing loud or disturbing noises. RF can affect all hearing aids. There are currently no industry standards for these levels, so reasonable care should be taken and testing is recommended.

The following design practices are fairly standard and also facilitate access and use by users with disabilities:

9. Use media misinsertion blocking.

Blocking assists all users as a memory aid, but it especially helps those with low vision or cognitive impairments who might forget or misinterpret how to insert media.

10. Offer components that allow for use of alternative input devices.

This assists those who use alternative input or output devices because of the nature of their reduced ability.

11. Provide adjustable height, swivel, and so on where appropriate.

Adjustable components assist those who do not have a full range of movement; displays and input devices can be oriented toward the user.

12. Minimize operation noise levels.

In general, quieter components, such as fans, disk drives, and so on, are easier to use for users with neural hearing loss or hearing aids.

13. Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.

Softening component edges assists those with reduced motor control, minimizing the potential for injury.

14. Manufacture outer surfaces using only hypoallergenic materials.

Chromium and nickel are known to cause allergic reactions in some users and should therefore be avoided in any part that could come into contact with users' skin during normal use.

Input and Controls

The ability to operate a computer directly depends on the ability to use its input devices and controls. For many people with physical or visual disabilities, using a computer depends either on the design of the input and control devices or on the computer's ability to substitute other control mechanisms (such as use alternative input devices or software controls). Users who are blind cannot use input mechanisms that require hand-eye coordination, such as a mouse or a control with no tactile or auditory reference.

Easier-to-operate controls are appreciated by all users, as is the ability to connect and use alternative preferred input devices.

Hardware design strategies for providing greater access to input and control functions include the following:

1. Allow connection, substitution, or addition of alternative input devices.

A second serial port is helpful for those using SerialKeys software in Windows 95 to provide alternative access, as well as for blind users who typically use speech synthesizers with serial connections. For users who cannot use standard input devices (even with software extensions such as StickyKeys), the availability of an external keyboard and mouse connection on portable systems allows the user to substitute specially designed keyboards or pointing devices.

2. Design all controls to operate from the keyboard.

This allows users with restricted reach or motor skills to operate controls on the CPU, monitor, and so on that they would otherwise be unable to use. It also allows these users to operate the controls from any other keyboard they might use.

3. Mount all controls on the front of the device.

By placing all controls facing the user, all users will have better access.

4. Limit button design primarily to push-button controls.

Push-button controls assist those with reduced motor control and those using head or mouth sticks or other alternative pointing devices.

5. Use concave buttons, especially where sustained force is required.

Concave buttons help keep fingers or pointers from slipping, assisting those with reduced finger or motor control (such as tremor) and those who must use headsticks or other pointing devices.

6. Avoid twisting motions.

Users with some disabilities, such as cerebral palsy or arthritis, find twisting motions difficult or impossible. Instead, use push-button or edge controls.

7. Minimize force required for operation.

A maximum force of 2 Newtons for any operation is advised. For controls, use a light touch or substitute manual mechanisms with power-driven mechanisms to achieve sustained or heavy touch.

8. Make all controls operable with one hand.

This allows individuals who have only one hand or who use assistive pointing devices to operate the controls.

9. Avoid capacitance-based controls.

Capacitance-based controls require contact with the human skin. Avoiding these types of controls allows users with assistive pointing devices or artificial limbs to use the system.

10. Use functional grouping and layout of controls.

Functional grouping assists those with low vision or cognitive impairments to quickly find the right keys. Examples of functional sets are direction keys and control keys. The keys can be grouped by color (making sure to take color blindness into account) or by other design characteristics, such as shape or feel.

11. Make controls tactually discernible.

This includes locator ridges or nibs on the home keys. Flat-membrane keypads with no tactile features should be avoided because they provide no feedback on the location of the buttons.

12. Make the state of non-momentary controls tactually discernible.

This allows those who have low vision or who are blind to discern the state of a control.

13. Provide tactile and audible actuation feedback for controls.

People who have low vision or who are blind require non-visual signals to determine when a key has been pressed.

14. Avoid keys that cannot be read or simulated by software.

Many users rely on software programs that either detect or simulate keystrokes. For example, the StickyKeys, SlowKeys, and SerialKeys features in Windows 95 rely on this ability when compensating for a user's difficulty with the keyboard. Blind users can also query the state of toggle keys using software. Any nonstandard keys, such as the Fn key, should produce scan codes that trigger their functionality.

15. Maximize size of controls within the space available.

This makes operation easier for those with low vision and those with limited dexterity who might have difficulty manipulating small controls.

16. Space the controls a sufficient distance to allow for tactile and visual discrimination.

This facilitates access by users with visual impairments as well as assisting those with reduced motor control. For example, on keyboards, key-top spacing should be approximately one-half of the key width. For small controls, spacing can be tighter, but functional grouping should be maintained to minimize pressing several controls at once.

17. Design stable controls.

Unintended activation should not change the adjustment state of the control. Some users with reduced motor control or blindness might inadvertently change the setting of one control while activating another. Controls or input devices should be designed to prevent this.

18. Manufacture input guards or provide mounting for guards.

Keyguards go over the keyboard and allow users to press one key at a time while resting their hands on the keyguard surface. They allow those with reduced strength or reduced motor control to have more control over their input. Guards can also be made for other input devices, where applicable. The FilterKeys features in Windows 95 allows direct access for many users, but others benefit further from hardware guards. Manufacturers should also ensure that grooves or holes are made in the edge of the device to allow for mounting a guard.

19. Provide stable keyboards.

Features such as non-slip feet assist those with reduced motor control who might otherwise inadvertently move the keyboard when trying to use it.

20. Remove left-right bias.

Designing equipment with no left-right bias assists those who have use of only one hand or who are left-handed. Where this is not possible, alternatives should be provided, such as providing support for external numeric keypads with a built-in numeric keypad.

21. Put less used controls and features behind a door.

Putting seldom-used controls behind a door avoids accidental activation and also assists people with cognitive disabilities—and all users in general—by reducing the number of visible controls. Ensure that the door is physically accessible.

Labeling

The ability to read labels is important to ensure that users are able to detect and recognize controls, connectors, and media interfaces. Users with low vision or blindness often have difficulty if these labels are printed in small or low-contrast type. All users have difficulty with small labels on the back or in hard-to-view areas of the product.

Hardware design strategies for providing greater access to labels include the following:

1. Use large, high-contrast, bold stroke, sans serif lettering; avoid using artwork behind text.

This allows users with low vision or reduced vision to more easily read the lettering.

2. Use tactually distinct icons for controls, connectors, and legends.

Raised icons (raised at least 1/32 inch) allow users who are blind to more easily discern an item's label by touch. They also allow any user to identify a component located out of view, such as on the back of the unit.

3. Provide optional Braille and tactile labels.

This allows users who are blind the option of customizing labels on the unit.

4. Use simple, concise language and avoid abbreviations in labels.

This helps make labels easier to understand for everyone, especially for people with cognitive disabilities and first-time users.

Documentation

Modern multimedia computers and peripherals require more documentation than ever. For users with low vision or blindness, standard print manuals might be unusable. Users with physical disabilities might be unable to hold perfect-bound manuals open. All users would welcome manuals that are easier to understand.

Documentation design strategies for providing greater access and usability include the following:

1. Provide electronic documentation (ASCII).

This enables generation of Braille, speech, and variable-sized text outputs for users with blindness, low vision, and cognitive or physical disabilities

2. Provide text descriptions of graphical information.

Written descriptions of illustrations, graphs, and so on allow users with blindness or low vision to access the information in the graphic.

3. Use clear, simple language.

Clear and concise writing benefits everyone, but it is especially helpful to those for whom English is a second language (including sign language) or for users with cognitive disabilities.

4. Bind manuals in a way that allows the manual to lie open.

A manual that lies flat is easier to manipulate by the user who has one hand or uses a mouthstick.

5. Provide manuals in alternative formats such as large print or Braille.

This allows users with blindness or low vision access to the information. Recommended large print is 18-point sans serif.

6. Use high-contrast layouts.

Users with color blindness or low vision require high contrast to access printed information.

7. Use colors that reproduce well on copy machines.

Avoid colors that copy all gray or low contrast. Users with low vision often enlarge the information in manuals using a copy machine.

8. Provide online help.

Online help allows users to access information without having to refer to manuals.

9. Avoid conveying information by color alone.

Users with low vision or color blindness may have difficulty perceiving certain colors. Users who are blind scan the documentation to convert it to ASCII text.

Accessibility Guidelines for PC Design

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

1. Accessibility recommendations for physical design (casing)

Recommended

Manipulation and Physical Design:

- 2 Sculpt or bevel device or plug entry slots.
- 4 Make latches operable with one hand.
- 8 Ensure that devices do not generate electromagnetic or RF fields that would affect users with hearing aids.
- 10 Offer separate components that allow for use of alternative devices.
- 11 Provide adjustable height, swivel, and so on where appropriate.
- 12 Minimize operation noise levels.
- 13 Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.
- 14 Manufacture outer surfaces using only hypoallergenic materials.

Input and Controls:

- 4 Limit button design primarily to push-button controls.
- 5 Use concave buttons, especially where sustained force is required.
- 6 Avoid twisting motions.
- 7 Minimize force required for operation.
- 8 Make all controls operable with one hand.
- 11 Make controls tactually discernible.
- 13 Provide tactile and audible actuation feedback for controls.
- 15 Maximize size of controls within the space available
- 16 Space the controls a sufficient distance to allow for tactile and visual discrimination.

Labeling:

- All points in the Labeling section of this appendix

Documentation:

- All points in the Documentation section of this appendix

Accessibility Guidelines for PC Card

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

2. Accessibility recommendations for PC Cards

Recommended

Labeling:

- All points in the Labeling section of this appendix

Documentation:

- All points in the Documentation section of this appendix

Accessibility Guidelines for Input Components

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

3. Accessibility recommendations for pointing devices

Recommended

Manipulation and Physical Design:

- 8 Ensure that devices do not generate electromagnetic or RF fields that would affect users with hearing aids.
- 10 Offer components that allow for use of alternative input devices.
- 13 Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.
- 14 Manufacture outer surfaces using only hypoallergenic materials.

Input and Controls:

- 1 Allow connection, substitution, or addition of alternative input devices.
- 2 Design all controls to operate from the keyboard.
- 4 Limit button design primarily to push-button controls.
- 5 Use concave buttons, especially where sustained force is required.
- 6 Avoid twisting motions.
- 7 Minimize force required for operation.
- 8 Make all controls operable with one hand.
- 9 Avoid capacitance-based controls.
- 10 Use functional grouping and layout of controls.

- 11 Make controls tactually discernible.
- 13 Provide tactile and audible actuation feedback for controls.
- 16 Space the controls a sufficient distance to allow for tactile and visual discrimination.
- 17 Design stable controls.
- 18 Manufacture input guards or provide mounting for guards.
- 20 Remove left-right bias.

4. Accessibility recommendations for keyboards

Recommended

Visual Displays and Indicators:

- 3 Make LCD and LED indicators, warning, and alert lights software-readable.

Manipulation and Physical Design:

- 8 Ensure that devices do not generate electromagnetic RF fields that would affect users with hearing aids.
- 10 Offer components that allow for use of alternative input devices.
- 11 Provide adjustable height, swivel, and so on where appropriate
- 13 Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.
- 14 Manufacture outer surfaces using only hypoallergenic materials.

Input and Controls:

- 1 Allow connection, substitution, or addition of alternative input devices.
- 2 Design all controls to operate from the keyboard.
- 3 Mount all controls on the front of the device.
- 4 Limit button design primarily to push-button controls.
- 5 Use concave buttons, especially where sustained force is required.
- 6 Avoid twisting motions.
- 7 Minimize the force required for operation.
- 8 Make all controls operable with one hand.
- 9 Avoid capacitance-based controls.
- 10 Use functional grouping and layout of controls.
- 11 Make controls tactually discernible.
- 12 Make the state of non-momentary controls tactually discernible.
- 13 Provide tactile and audible actuation feedback for controls.
- 14 Avoid keys that cannot be read or simulated by software.

- 15 Maximize size of controls within the space available.
- 16 Space the controls a sufficient distance to allow for tactile and visual discrimination.
- 18 Manufacture input guards or provide mounting for guards.
- 19 Provide stable keyboards.
- 20 Remove left-right bias.

Labeling:

- All points in the Labeling section of this appendix.

Documentation:

- All points in the Documentation section of this appendix.

Accessibility Guidelines for Display Monitors

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

5. Accessibility guidelines for display monitors

*Recommended***Visual Displays and Indicators:**

- 1 Minimize glare.
- 2 Avoid 5-Hz to 50-Hz refresh rate or flicker rate.
- 3 Make LCD and LED indicators, warning, and alert lights software-readable.
- 4 Provide contrast and brightness controls.
- 5 Provide a display connector for an external or additional monitor.
- 6 Provide adjustable monitors.

Manipulation and Physical Design:

- 4 Make latches operable with one hand.
- 8 Ensure that devices do not generate electromagnetic or RF fields that would affect users with hearing aids.
- 10 Offer separate components that allow for use of alternate input devices.
- 11 Provide adjustable height, swivel, and so on where appropriate.
- 12 Minimize operation noise levels.
- 13 Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.
- 14 Manufacture outer surfaces using only hypoallergenic materials.

Input and Controls:

- 2 Design all controls to operate from the keyboard.
- 3 Mount all controls on the front of the device.
- 4 Limit button design primarily to push-button controls.
- 5 Use concave buttons, especially where sustained force is required.
- 6 Avoid twisting motions.
- 7 Minimize the force required for operation.
- 8 Make all controls operable with one hand.
- 9 Avoid capacitance-based controls.
- 10 Use functional grouping and layout of controls.
- 11 Make controls tactually discernible.
- 12 Make the state of non-momentary controls tactually discernible.
- 13 Provide tactile and audible actuation feedback for controls.
- 15 Maximize size of controls within the space available.
- 16 Space the controls a sufficient distance to allow for tactile and visual discrimination.
- 17 Design stable controls.

Labeling:

- All points in the Labeling section of this appendix.

Documentation:

- All points in the Documentation section of this appendix

Accessibility Guidelines for Audio Components

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

6. Accessibility features for headphones

Recommended

Sound:

- 1 Provide a headphone jack.
- 2 Maximize the range of volume adjustment.
- 5 Provide a visual indication of important sounds generated in normal computer operation.
- 6 Send hardware-generated beeps to the operating system.

7. Accessibility features for microphones

Recommended

Sound:

- 7 Place the microphone in the orientation recommended by the microphone manufacturer.

Labeling:

- All points in the Labeling section of this appendix.

8. Accessibility features for speakers

Recommended

Sound:

- 2 Maximize the range of volume adjustment.
- 3 Direct speakers toward the user or allow user to adjust the speakers.
- 8 Include a speech-capable sound system.
- 9 Reduce noise level of operating internal components.

Note: If the audio components have any built-in controls, for example, volume controls and so on, they should follow the guidelines listed under “Input and Controls” earlier in this appendix.

Accessibility Guidelines for Storage Devices

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

9. Recommendations for 3.5-inch floppy disk drives

Recommended

Visual Displays and Indicators:

- 3 Make LCD and LED indicators, warning lights, and alert lights software-readable.

Sound:

- 4 Provide a visually distinct indicator for all alerts or warning sounds created by hardware.
- 5 Provide visual indication of important sounds generated in normal computer operation.
- 6 Provide visual indication of hardware-generated noises to the operating system.
- 9 Reduce noise level of operating internal parts.

Manipulation and Physical Design:

- 1 Eject media a sufficient distance for grasping.
- 2 Sculpt or bevel device entry slots.
- 3 Provide self-orienting or clearly tactually marked plugs.
- 4 Make latches operable with one hand.
- 5 Minimize the force required for inserting and retrieving media.
- 6 Ensure that media takes rough handling, and use caddies for media that do not.
- 7 Provide error flags for misinserted media, especially CDs.
- 8 Ensure that devices do not generate electromagnetic or RF fields that would affect users with hearing aids.
- 9 Use media misinsertion blocking.
- 10 Use capacitance-based controls.
- 12 Minimize operation noise levels.
- 14 Provide tactile/audible feedback.

Input and Controls:

- 1 Allow connection, substitution, or addition of alternative input devices.
- 2 Design controls to operate from the keyboard.
- 3 Mount all controls mounted on the front of the device.
- 4 Limit button design primarily to push-button controls.
- 5 Use concave buttons, especially where sustained force is required.
- 6 Avoid twisting motions.
- 7 Minimize the force required for operation.
- 8 Make all controls operable with one hand.
- 11 Make controls tactually discernible.
- 15 Maximize size of controls within the space available.

Labeling:

- 2 Use tactually distinct icons for controls, connectors, and legends.
- 3 Provide optional Braille and tactile labels.

Documentation:

- All points in the Documentation section of this appendix

10. Accessibility recommendations for CD drives*Recommended***Visual Displays and Indicators:**

- 3 Make LCD and LED indicators, warning, and alert lights software-readable.

Sound:

- 4 Provide a visually distinct indicator for all alerts or warning sounds created by hardware.
- 5 Provide visual indication of important sounds generated in normal computer operation.
- 6 Provide hardware-generated beeps to the operated systems.
- 9 Reduce noise level of operating internal parts.

Manipulation and Physical Design:

- 1 Eject media a sufficient distance for grasping.
- 2 Sculpt or bevel device entry slots.
- 4 Make latches operable with one hand.
- 5 Minimize the force required for inserting and retrieving media.
- 6 Ensure that media stands up to rough handling; use caddies for media that do not.
- 7 Provide error flags for misinserted media, especially CDs.
- 8 Ensure that devices do not generate electromagnetic or RF fields that would affect users with hearing aids.
- 9 Use media misinsertion blocking.
- 12 Minimize operation noise levels.
- 13 Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.

Input and Controls:

- 1 Allow connection, substitution, or addition of alternative input devices.
- 2 Design all controls to operate from the keyboard.
- 3 Mount all controls on the front of the device.
- 4 Limit button design primarily to push-button controls.
- 5 Use concave buttons, especially where sustained force is required.
- 6 Avoid twisting motions.
- 7 Minimize the force required for operation.
- 8 Make all controls operable with one hand.
- 11 Make controls tactually discernible.
- 13 Provide tactile and audible actuation feedback for controls.
- 15 Maximize size of controls within the space available.

Labeling:

- 2 Use tactually distinct icons for controls, connectors, and legends.
- 3 Provide optional Braille and tactile labels.

Documentation:

- All points in the Documentation section of this appendix

Accessibility Guidelines for Printers

This section presents summary lists of recommendations for design issues related to access for persons with disabilities. Item numbers are based on lists in related sections of this appendix.

11. Accessibility for printers

Recommended

Visual Displays and Indicators:

- 3 Make LCD and LED indicators, warning lights, and alert lights software-readable.

Sound:

- 4 Provide a visually distinct indicator for all alerts or warning sounds created by hardware.
- 5 Provide visual indication of important sounds generated in normal computer operation.
- 6 Send hardware-generated beeps to the operating system.
- 9 Reduce noise level of operating internal components.

Manipulation and Physical Design:

- 1 Eject media a sufficient distance for grasping.
- 2 Sculpt or bevel device or plug entry slots.
- 4 Make latches operable with one hand.
- 5 Minimize force required for inserting and retrieving media.
- 7 Provide error flags for misinserted media, especially CDs.
- 8 Ensure that devices do not generate electromagnetic or RF fields that would affect users with hearing aids.
- 12 Minimize operation noise levels.
- 13 Eliminate hard edges or sharp corners that could cause injury or inhibit correct device placement.
- 14 Manufacture outer surfaces using only hypoallergenic materials.

Input and Controls:

- 1 Allow connection, substitution, or addition of alternative input devices.
- 2 Design all controls to operate from the keyboard.
- 3 Mount all controls on the front of the device.
- 4 Limit button design primarily to push-button controls.
- 5 Use concave buttons, especially where sustained force is required.
- 6 Avoid twisting motions.
- 7 Minimize the force required for operation.
- 8 Make all controls operable with one hand.
- 9 Avoid capacitance-based controls.
- 10 Use functional grouping and layout of controls.
- 11 Make controls tactually discernible.
- 12 Make the state of non-momentary controls tactually discernible.
- 13 Provide tactile and audible actuation feedback for controls.
- 15 Maximize size of controls within the space available.
- 16 Space the controls a sufficient distance to allow for tactile and visual discrimination.
- 20 Remove left-right bias.

Labeling:

- All points in the Labeling section of this appendix.

Documentation:

- All points in the Documentation section of this appendix.

Accessibility References and Resources

The following represents some of the references, services, and tools available to help build hardware and software that addresses accessibility needs.

Accessibility Publications

The following publications provide supplementary information.

Berliss, J. R. *Checklists for implementing accessibility in computer laboratories at colleges and universities*. University of Wisconsin-Madison, Trace Research and Development Center, 1990.

Fontaine, P. *Writing Accessible HTML Documents*. General Services Administration, 1995.

Lowney, G. C. *The Microsoft Windows Guidelines for Accessible Software Design*. Microsoft Corporation, Redmond, Wash., 1995.

Novak, M. (Ed.) *General Input Device Emulating Interface: Version 2*. University of Wisconsin-Madison, Trace Research and Development Center, 1994.

Thoren, Clas (Ed.) *Nordic guidelines for computer accessibility*. Gotab, Sthlm, 1998.

Vanderheiden, G. C. *Consideration in the design of computers and operating systems to increase their accessibility to persons with disabilities*. University of Wisconsin-Madison, Trace Research and Development Center, 1988.

———. *Making software more accessible to people with disabilities*. University of Wisconsin-Madison, Trace Research and Development Center, 1991.

——— and Vanderheiden, K. R. *Accessibility Design Guide I: Guidelines for the Design of Consumer Products to Increase Their Accessibility to Persons with Disabilities or Who Are Aging*. University of Wisconsin-Madison, Trace Research and Development Center, 1991.

Resources for Accessibility Design

This section lists some documents and services related to accessibility design.

Microsoft Windows Guidelines for Accessible Software Design

Describes techniques for developing software applications that are usable by people with disabilities. This document is included on the Microsoft Developer Network (MSDN) CD-ROM. To obtain additional copies or for information about other Microsoft products and services for people with disabilities, contact:

Microsoft Sales Information Center
One Microsoft Way
Redmond, WA 98052-6393
Voice: (800) 426-9400
Text Telephone: (800) 892-5234
Fax: (206) 635-6100

Research and Product Information

For information on research and development concerning technology, communication, and disabilities, or for catalogs of accessibility products and service providers, contact:

Trace Research and Development Center
Waisman Center and Department of Industrial Engineering
University of Wisconsin
Madison, WI 53705
E-mail: info@Trace.Wisc.Edu
Fax: (608) 262-8848
FTP, Gopher, and WWW servers: trace.wisc.edu

For a list of listserve discussions, send "LISTS" to listproc@trace.wisc.edu.

Documentation in Accessible Formats

Recording for the Blind and Dyslexic, Inc., is an organization that can assist in preparing documentation in accessible formats, including electronic text and audio tape. Contact:

Recording for the Blind and Dyslexic, Inc.
20 Roszel Road
Princeton, NJ 08540
Voice telephone: (800) 221-4792
Fax: (609) 987-8116

For a list of organizations that can assist in converting documentation into large print or Braille, contact the Microsoft Sales Information Center at the address listed above.

Assistive Technology Programs

For general information or recommendations for how computers can help specific users, consult a trained evaluator. An assistive technology program will provide referrals to programs and services that are available to you. To locate the assistive technology program nearest you, contact:

National Information System
Center for Developmental Disabilities
Midland Center
Education Building
8301 Sarrow Road
Columbia, SC 29203
Voice or text telephone: (803) 777-4435
Fax: (803) 935-5250

Closed Captioning and Video Description

The following service providers can assist in adding closed captions or video description to video tape and film:

The Caption Center
125 Western Avenue
Boston, MA 02134
Voice/text telephone: (617) 492-9225
Fax: (617) 562-0590

National Captioning Institute
5203 Leesburg Pike, Suite 1500
Falls Church, VA 22041

